CLAIMS

What is claimed is:

1. A method for determining whether a suspect 3-D surface has been copied from an original 3-D surface, comprising:

comparing umbilics of the two surfaces;

determining whether the suspect surface is a copy of the original surface responsive to said step of comparing.

2. The method of Claim 1, wherein the step of comparing umbilics comprises:

determining whether locations of the umbilics of the suspect surface match within a specified margin umbilics of the original surface.

3. The method of Claim 2, wherein the step of comparing umbilics further comprises:

determining whether pattern types of umbilics of the suspect surface match pattern types of corresponding umbilics of the original surface.

4. The method of Claim 1, further comprising:

manipulating at least one of the surfaces so that characteristics of the two surfaces approximately match.

5. The method of Claim 4, wherein the step of manipulating comprises at least one of translating, rotating and scaling.

6. The method of Claim 1, further comprising:

performing a weak test, the weak test comprising:

comparing corresponding points of the two surfaces to check that the corresponding points are located within a specified distance margin of each other.

7. The method of Claim 6, the step of comparing umbilics being performed responsive to the weak test.

8. The method of Claim 6, further comprising:
modifying the specified margin; and
repeating the weak test using the modified margin.

9. The method of Claim 6, the weak test generating statistics.

10. The method of Claim 9, the step of comparing umbilics being performed responsive to the generated statistics.

11. The method of Claim 6, further comprising:
performing an intermediate test, comprising:
on each surface, computing the principal directions of lines of curvature at each grid point; and
comparing the computed directions of lines of curvature for corresponding gridpoints on the surfaces to check that the directions are within a specified angular margin of each other.

12. The method of Claim 11, further comprising:
determining whether the suspect surface is a copy of the original surface responsive to the intermediate test.

13. The method of Claim 11, the intermediate test being performed responsive to the weak test.

14. The method of Claim 11, the intermediate test being performed responsive to statistics generated by the weak test.

15. The method of Claim 11, further comprising:

modifying the angular margin; and

repeating the intermediate test using the modified angular margin.

16. The method of Claim 11, the intermediate test generating statistics.

17. The method of Claim 16, the step of comparing umbilics being performed responsive to the statistics generated by the intermediate test.

18. The method of Claim 11, the step of comparing umbilics being performed responsive to the intermediate test.

19. The method of Claim 1, further comprising:

performing an intermediate test, comprising:

on each surface, computing the principal directions of lines of curvature at each grid point; and

comparing the computed directions of lines of curvature for corresponding gridpoints on the surfaces.

20. The method of Claim 19, wherein comparing the computed directions of lines of curvature comprises checking that the directions are within a specified angular margin of each other.

21. The method of Claim 20, further comprising:

modifying the angular margin; and

repeating the intermediate test using the modified angular margin.

22. The method of Claim 19, the intermediate test generating statistics.

23. The method of Claim 22, the step of comparing umbilics being performed responsive to the statistics generated by the intermediate test.

24. The method of Claim 19, further comprising:

determining whether the suspect surface is a copy of the original surface responsive to the intermediate test.

25. The method of Claim 19, the step of comparing umbilics being performed responsive to the intermediate test.

26. The method of Claim 1, wherein the surfaces are closed.

27. The method of Claim 1, wherein the surfaces are bordered.

28. The method of Claim 1, wherein at least one of the surfaces is represented using parametric modeling.

29. The method of Claim 28 wherein parametric modeling is based on non-uniform rational B-splines (NURBS).

30. The method of Claim 1, wherein at least one of the surfaces is represented using polygons.

31. The method of Claim 1, wherein at least on of the surfaces is represented using implicit modeling.

32. The method of Claim 1, further comprising:

maintaining a registry of 3-D shapes to be used in comparisons with the suspect surface.

33. The method of Claim 32, further comprising:

indexing the maintained shapes according to umbilic locations and their associated pattern types.

34. A method for determining whether a 3-D surface under examination has been copied from a 3-D surface model, comprising:

translating, rotating and scaling at least one of the surfaces, position, orientation and size of the surface under examination being approximately those of the model surface;

for each surface, determining a wireframe grid based on lines of curvature;

comparing grid points on the wireframes of the two surfaces;

if the grid points are within a specified margin of each other

determining umbilics and their associated patterns and comparing between the two surfaces;

if the umbilics between the two surfaces match within a specified margin and their associated patterns are the same, determining that the surface under examination has been copied from the model surface.

35. A method for determining whether a suspect 3-D surface has been copied from a 3-D surface model, comprising:

maintaining a registry of 3-D shapes to be used in comparisons with a suspect surface; and

comparing locations and associated pattern types of umbilics of the suspect surface with the shapes maintained in the registry.

36. The method of Claim 35, wherein the maintained shapes are indexed according to umbilic locations and their associated pattern types.

37. A system for determining whether a suspect 3-D surface has been copied from an original 3-D surface, comprising:

means for manipulating at least one of the surfaces;

means for determining, for each surface, a wireframe grid based on lines of curvature;

means for comparing grid points on the wireframes of the two surfaces;

means for determining umbilics and their associated patterns; and

means for comparing locations of the umbilics and for comparing pattern types associated with the umbilics.

38. A computer program product for determining whether a suspect 3-D surface has been copied from an original 3-D surface, the computer program product comprising a computer usable medium having computer readable code thereon, including program code which:

manipulates at least one of the surfaces;

determines, for each surface, a wireframe grid based on lines of curvature;

compares grid points on the wireframes of the two surfaces;

determines umbilics and their associated patterns; and

compares locations of the umbilics and pattern types associated with the umbilics.

39. A system for determining whether a suspect 3-D surface has been copied from an original 3-D surface, comprising:

a comparator which compares locations and associated pattern types of umbilics of the two surfaces;

an analyzer which determines whether the suspect surface is a copy of the original surface responsive to said comparator.

40. The system of Claim 39, the comparator determining whether locations of the umbilics of the suspect surface match within a specified margin umbilics of the original surface.

41. The system of Claim 40, the comparator further determining whether pattern types of umbilics of the suspect surface match pattern types of corresponding umbilics of the original surface.

42. The system of Claim 39, further comprising:

a manipulator which manipulates at least one of the surfaces so that characteristics of the two surfaces approximately match.

43. The system of Claim 42, wherein the manipulator performs at least one of translating, rotating and scaling.

44. The system of Claim 39, further comprising:

a weak condition tester which compares corresponding points of the two surfaces to check that the corresponding points are located within a specified distance margin of each other.

45. The system of Claim 44, the comparator comparing umbilics responsive to the weak test.

46. The system of Claim 44, the weak condition tester repeating its comparison with a modified distance margin.

47. The system of Claim 44, the weak condition tester generating statistics.

48. The system of Claim 47, the comparator comparing umbilics responsive to the generated statistics.

49. The system of Claim 44, further comprising:

an intermediate condition tester, which:

computes, for each surface, the principal directions of lines of curvature at each grid point; and

compares the computed directions of lines of curvature for corresponding gridpoints on the surfaces.

50. The system of Claim 49, the intermediate condition tester further determining whether the suspect surface is a copy of the original surface responsive to the intermediate test.

51. The system of Claim 49, the intermediate condition tester executing responsive to the weak condition tester.

52. The system of Claim 49, the intermediate condition tester performing responsive to statistics generated by the weak test.

53. The system of Claim 49, the intermediate condition tester repeating the intermediate test using a modified angular margin.

54. The system of Claim 49, the intermediate condition tester generating statistics.

55. The system of Claim 54, the comparator comparing umbilics responsive to the statistics generated by the intermediate condition tester.

56. The system of Claim 49, the comparator comparing umbilics responsive to the intermediate condition tester.

57. The system of Claim 39, further comprising

an intermediate condition tester, which:

computes, for each surface, the principal directions of lines of curvature at each grid point; and

compares the computed directions of lines of curvature for corresponding gridpoints on the surfaces.

58. The system of Claim 57, the intermediate condition tester comparing the computed directions of lines of curvature by checking that the directions are within a specified angular margin of each other.

59. The system of Claim 58, the intermediate condition tester

modifying the angular margin; and

repeating the intermediate test using the modified angular margin.

60. The system of Claim 57, the intermediate condition tester generating statistics.

61. The system of Claim 60, the comparator comparing umbilics responsive to the statistics generated by the intermediate condition tester.

62. The system of Claim 57, the intermediate condition tester further determining whether the suspect surface is a copy of the original surface.

63. The system of Claim 57, the comparator comparing umbilics responsive to the intermediate condition tester.

64. The system of Claim 39, wherein the surfaces are closed.

65. The system of Claim 39, wherein the surfaces are bordered.

66. The system of Claim 39, wherein at least one of the surfaces is represented using parametric modeling.

67. The system of Claim 66 wherein parametric modeling is based on non-uniform rational B-splines (NURBS).

68. The system of Claim 39, wherein at least one of the surfaces is represented using polygons.

69. The system of Claim 39, wherein at least one of the surfaces is represented using implicit modeling.

70. The system of Claim 39, further comprising:

a registry of 3-D shapes to be used in comparisons with the suspect surface.

71. The system of Claim 70, the maintained shapes being indexed according to umbilic locations and their associated pattern types.